Delaware River Basin SPARROW Model

US Geological Survey
Delaware NAWQA

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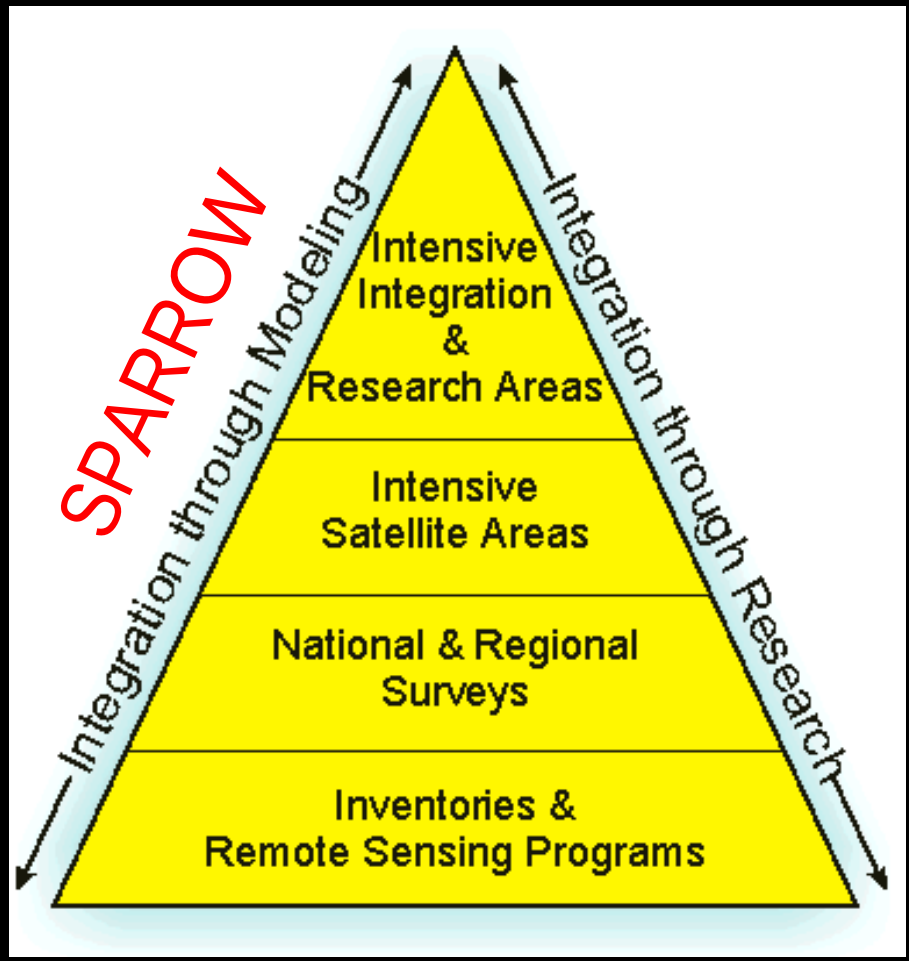
Delaware River Basin Collaborative Environmental Monitoring & Research Initiative CEMRI

The US Geological Survey, US Forest Service, National Park Service and other agencies are implementing a prototype environmental monitoring strategy to link hydrologic, forest, and water quality information across the landscapes of the Delaware River Basin.

CEMRI Framework



CEMRI promotes environmental monitoring across agencies, scales, and environmental resources to track complex environmental issues at a range of spatial and temporal scales.

Delaware Issues:

- Ecosystem Health & Change
  - Calcium Depletion
  - Carbon Cycling
  - Nutrient Cycling

Delaware River Basin SPARROW

SPARROW will integrate monitoring research at various scales in the Delaware River Basin to assess effects of nitrogen deposition and land use on water quality, forest productivity, forest health, and to assess the causes of water quality and environmental impacts.

Delaware SPARROW Project Objective

- To evaluate the distribution of Total Nitrogen (TN) and Total Phosphorous (TP) loads within the Delaware River Basin for time period 1990 - 2001
- To evaluate the statistical significance of factors affecting the predicted TN and TP distributions

USGS

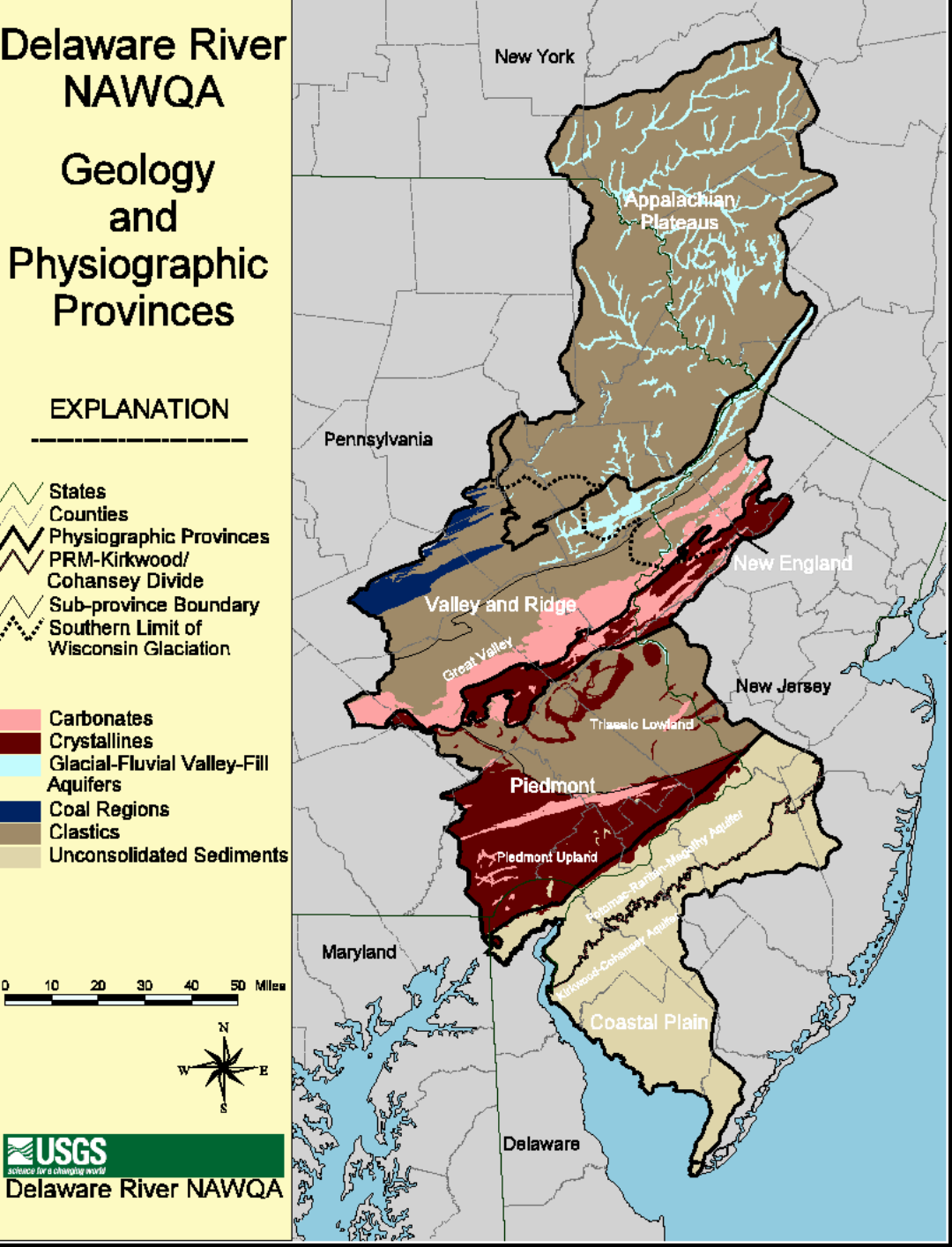
Delaware River Basin

Area > 12,000 square miles

Population over 7 million.

An additional 7 million people outside the basin rely on the Delaware for drinking water.

Delaware River is tidal up to Trenton



USGS

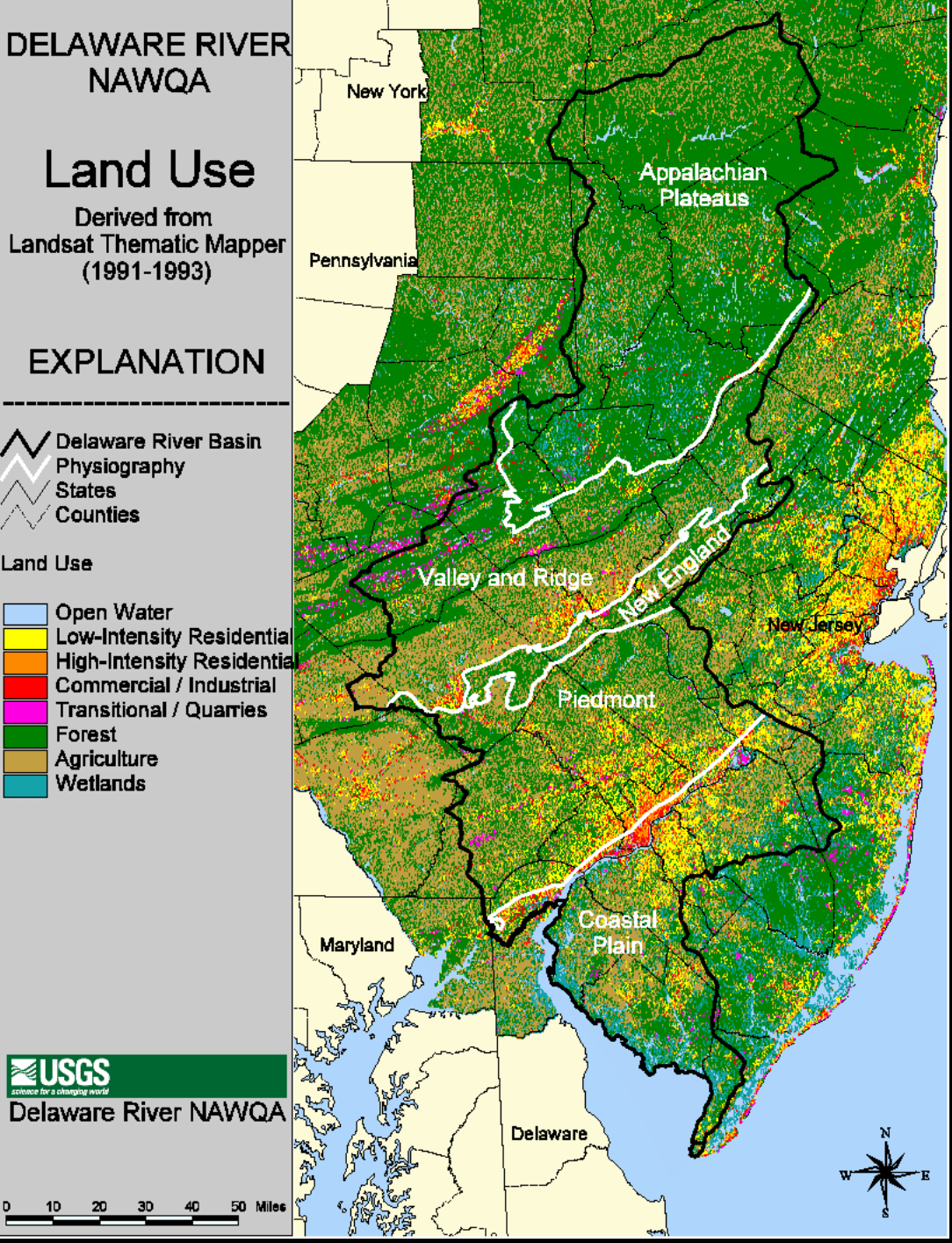
GEOLOGY

5 Physiographic Provinces.

Most of Basin is consolidated sedimentary and metamorphic rocks.

Northern third of basin was glaciated and has unconsolidated valley fill.

Coastal plain is unconsolidated sediments.



USGS

Basin-wide Land use

- 60% forest,
- 24% Agriculture,
- 9% urban.

80% of population lives in Piedmont and Coastal Plain which are ≥20% Urban land and ≥30% agriculture.

Appalachians are primarily Forest.

SPARROW Model Components

1. Stream Network and Associated Basins
2. Stream Loadings from monitoring data (dependent variable)
3. Nutrient Sources - Point Source, Nonpoint Source, Atmospheric Deposition, Others
4. Delivery Factors - Soils, Slope, Geology, Meteorology, Stream size, Others

Model Framework

SPARROW uses a digital network of streams and associated contributing basin areas for flow routing and as a spatial reference for all model parameters

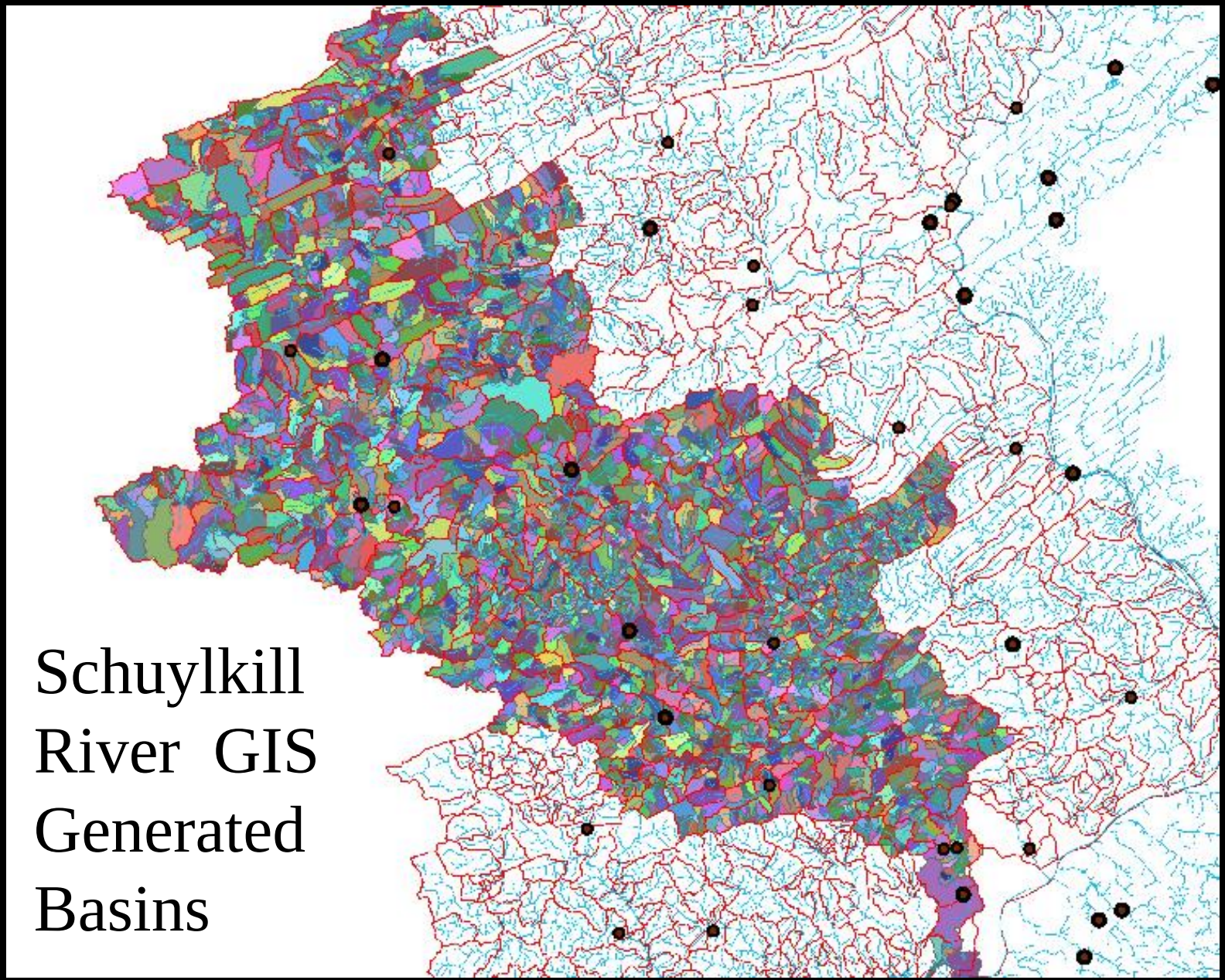
For Delaware Model

- 1:24,000 NHD digital stream network
- Use GIS to generate basin areas, flow, and travel times for stream reaches

Developing Areas, Streamflow, and Travel Times, for 1:24K NHD Stream Reaches

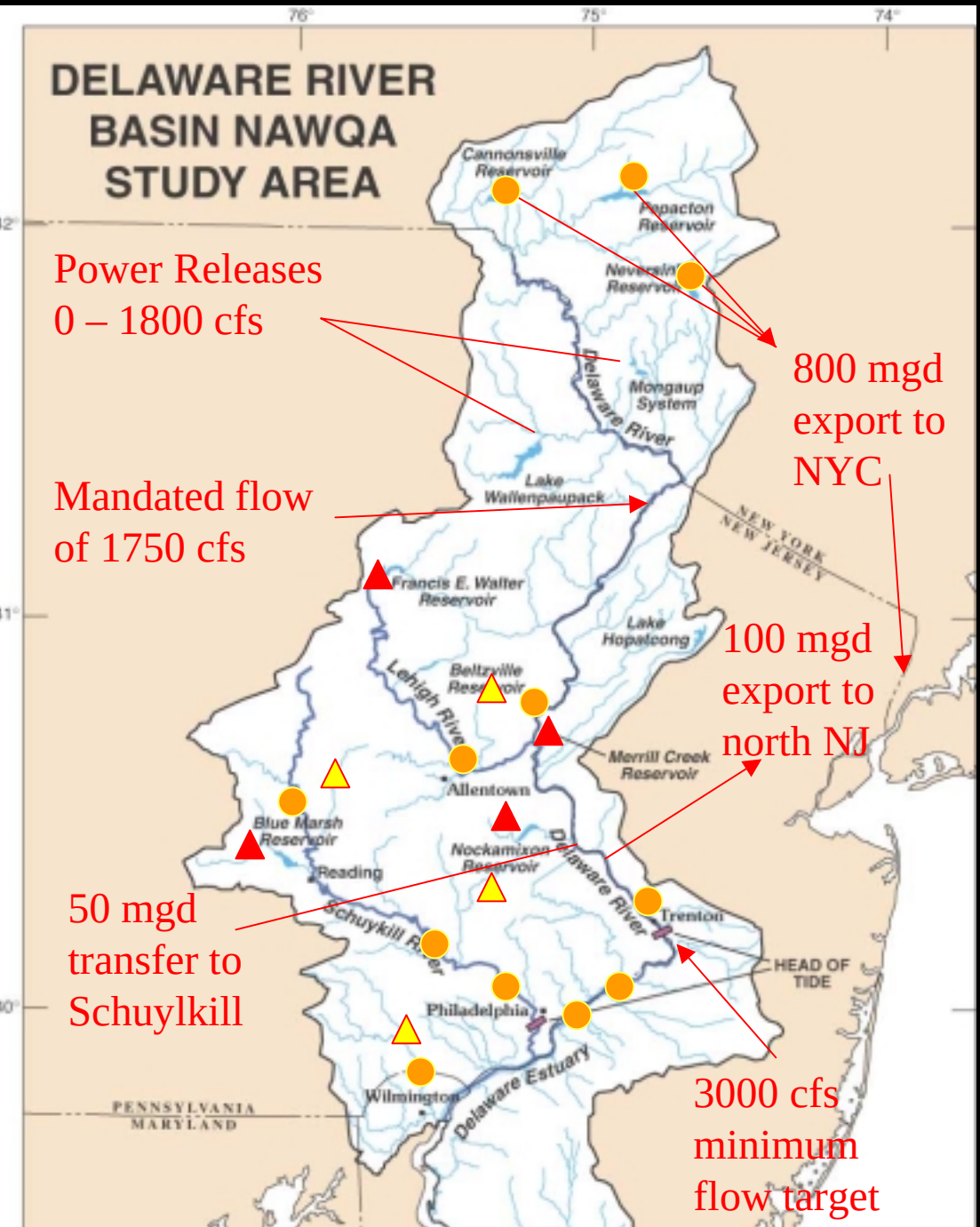
- Generate contributing areas for each river segment similar to NECB
- Apply runoff to those areas
- Use gage data to correct flow at sites that export water and have reservoirs
- Estimate travel time using Jobson method
- Excluding Estuary and tidal rivers

NHD Stream Network and Basins



Data Checks

- Catchment Areas
  - GIS areas vs gaged site areas
  - Rivers crossing HUC divides
- Flow
  - Estimated flow vs measured flow at gage sites
- Travel times
  - Calculated vs published travel times



FLOW CORRECTIONS

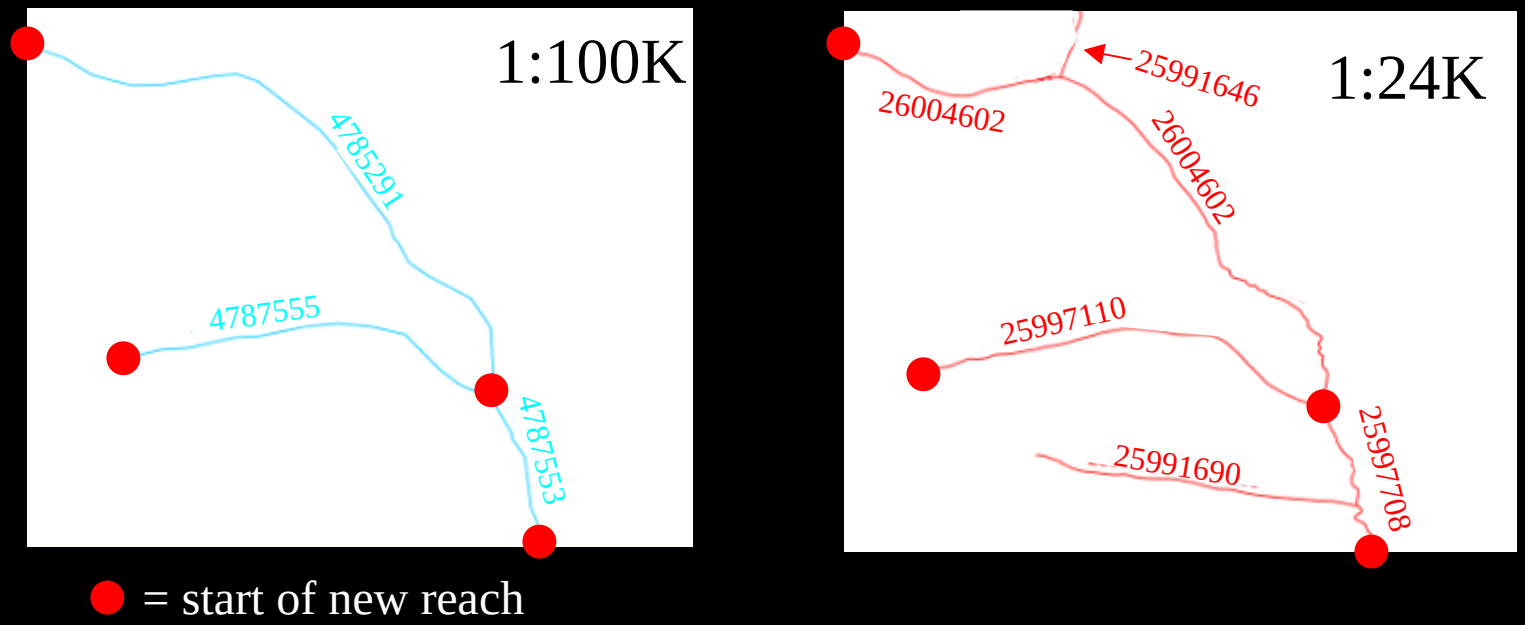
Reservoirs control mainstem flow and are used to export water from the basin.

Drinking water withdrawls at major metropolitan areas.

Many large STPs discharge to Estuary.

- Major drinking water intakes
- Flood control & flow augmentation
- Water Supply Reservoirs

A word on 1:24K NHD Streams



New reaches are added at 1:24K scale, but reach numbering is maintained from 1:100K scale. ***Difficult to distinguish between a reach above and below a new confluence.***

Calculated Nutrient Loads at monitoring stations

- Data from Federal and State Agencies
- 1975 to 2000 time period for predictors
- Usually 10 or more years of data at each site
- Loads calculated using ESTIMATOR for 1990 to 2001 time period

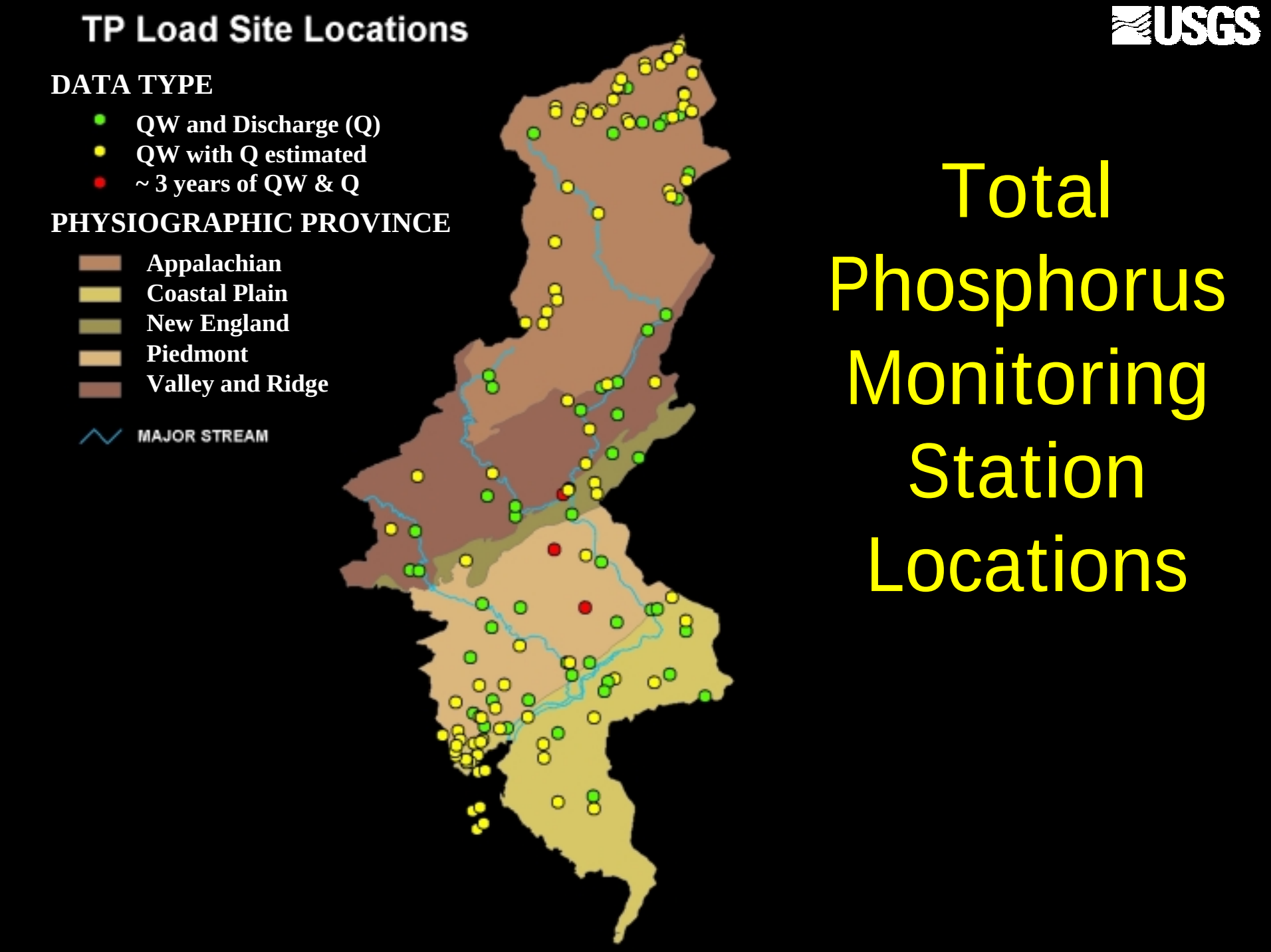
Total Phosphorous Load Sites

State	Area	Number of Sites		
• NJ	2969 sq mi	16	15	31
• NY	2363 sq mi	11	40	51
• PA	6465 sq mi	24	27	51
• DE	968 sq mi	6	23	29
TOTALS		57	105	162

Sites with measured flows and concentrations

Sites with some or all estimated flows

Total Sites


TP Load Site Locations
DATA TYPE
QW and Discharge (Q)
QW with Q estimated
~ 3 years of QW & Q
PHYSIOGRAPHIC PROVINCE
Appalachian
Coastal Plain
New England
Piedmont
Valley and Ridge
MAJOR STREAM
USGS
Total Phosphorus Monitoring Station Locations

Total Nitrate Load Sites

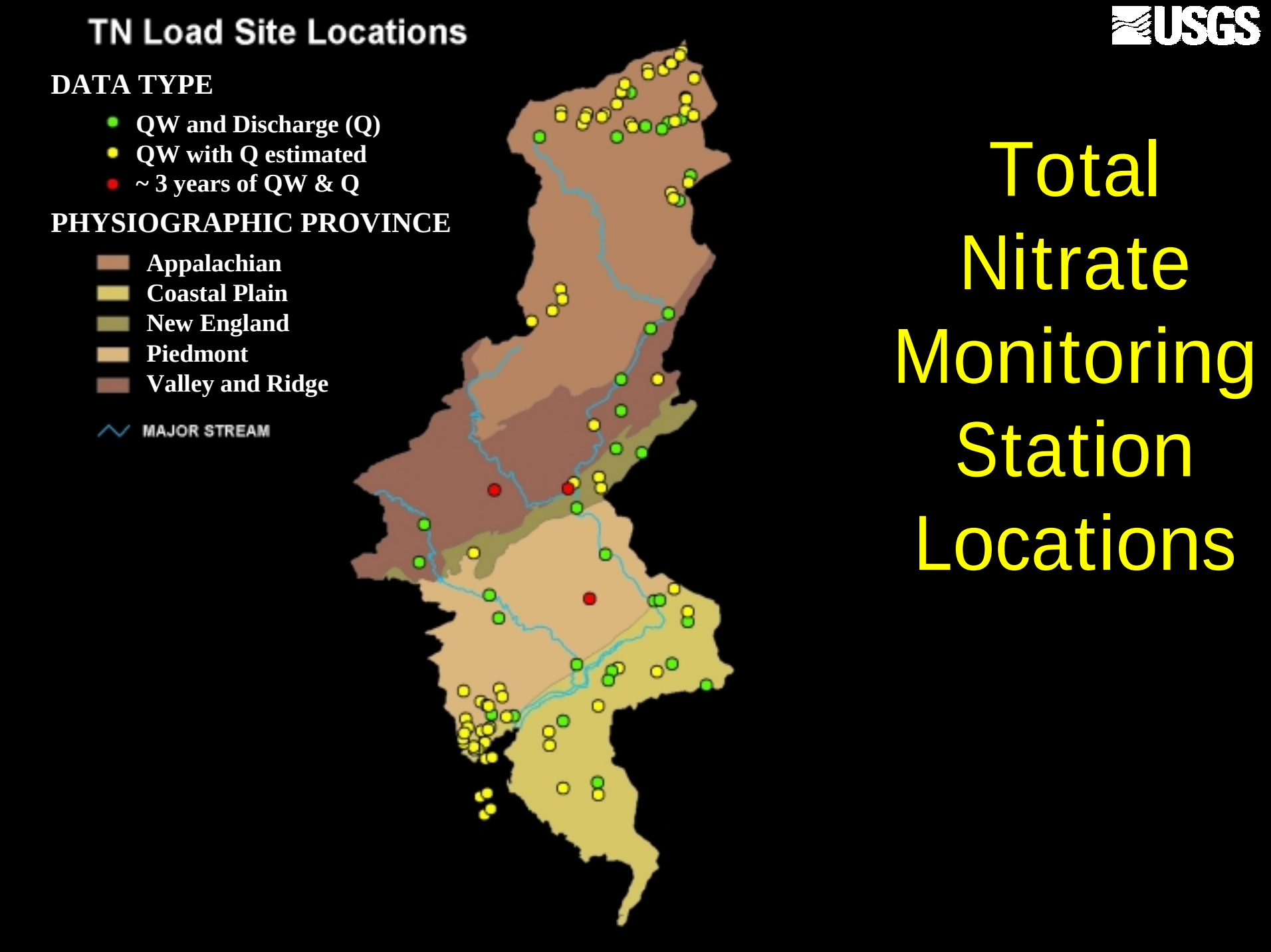
State	Area	Number of Sites			
• NJ	2969 sq mi	14	16	0	30
• NY	2363 sq mi	11	45	0	56
• PA	6465 sq mi	5	16	33?	54
• DE	968 sq mi	6	23	0	29
TOTALS		36	100	33?	>169

Sites with measured flows and concentrations

Sites with some or all estimated flows

Sites with some estimated concentrations

Total Sites

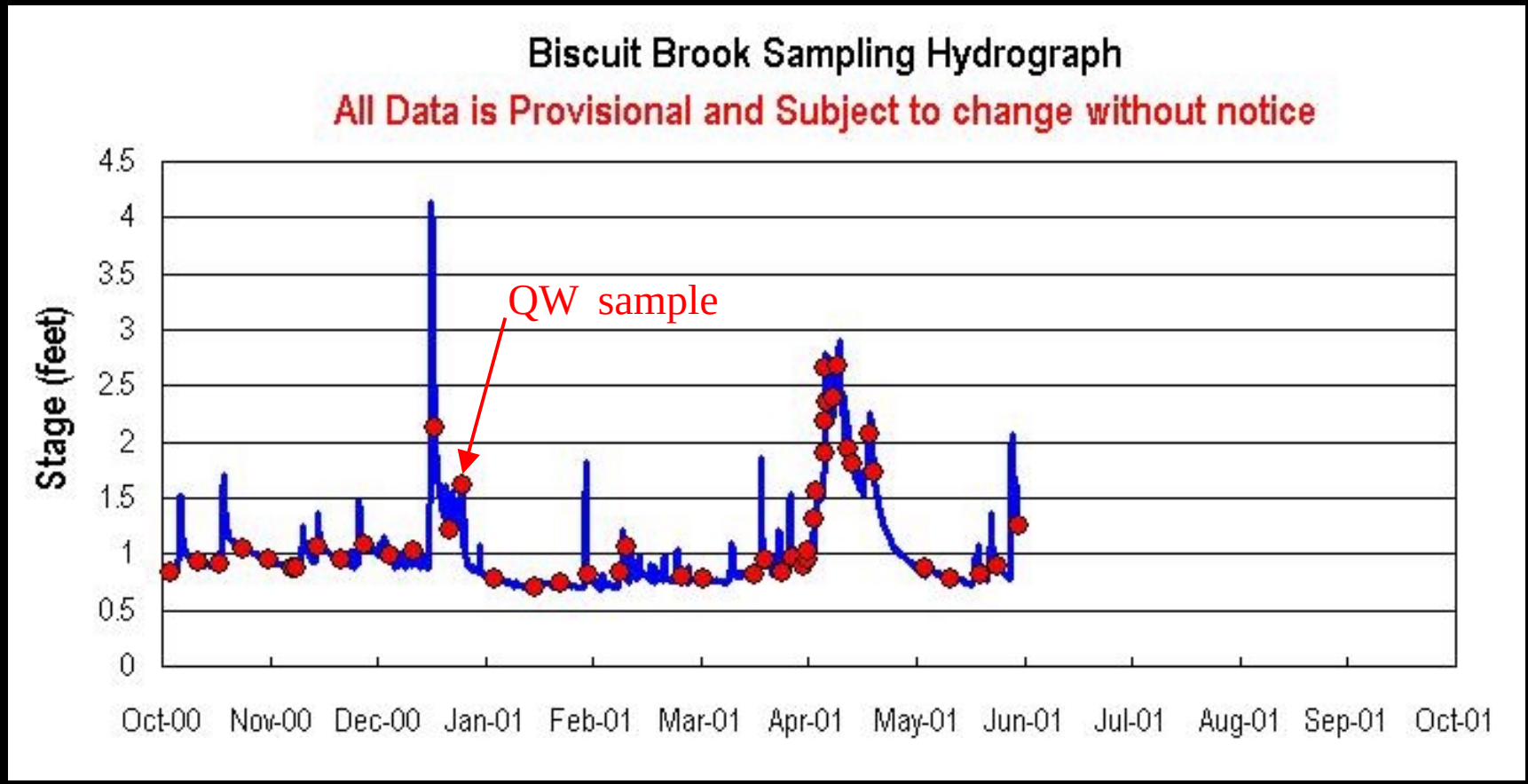

TN Load Site Locations
DATA TYPE
QW and Discharge (Q)
QW with Q estimated
~ 3 years of QW & Q
PHYSIOGRAPHIC PROVINCE
Appalachian
Coastal Plain
New England
Piedmont
Valley and Ridge
MAJOR STREAM
USGS
Total Nitrate Monitoring Station Locations

Estimator Load Calculations

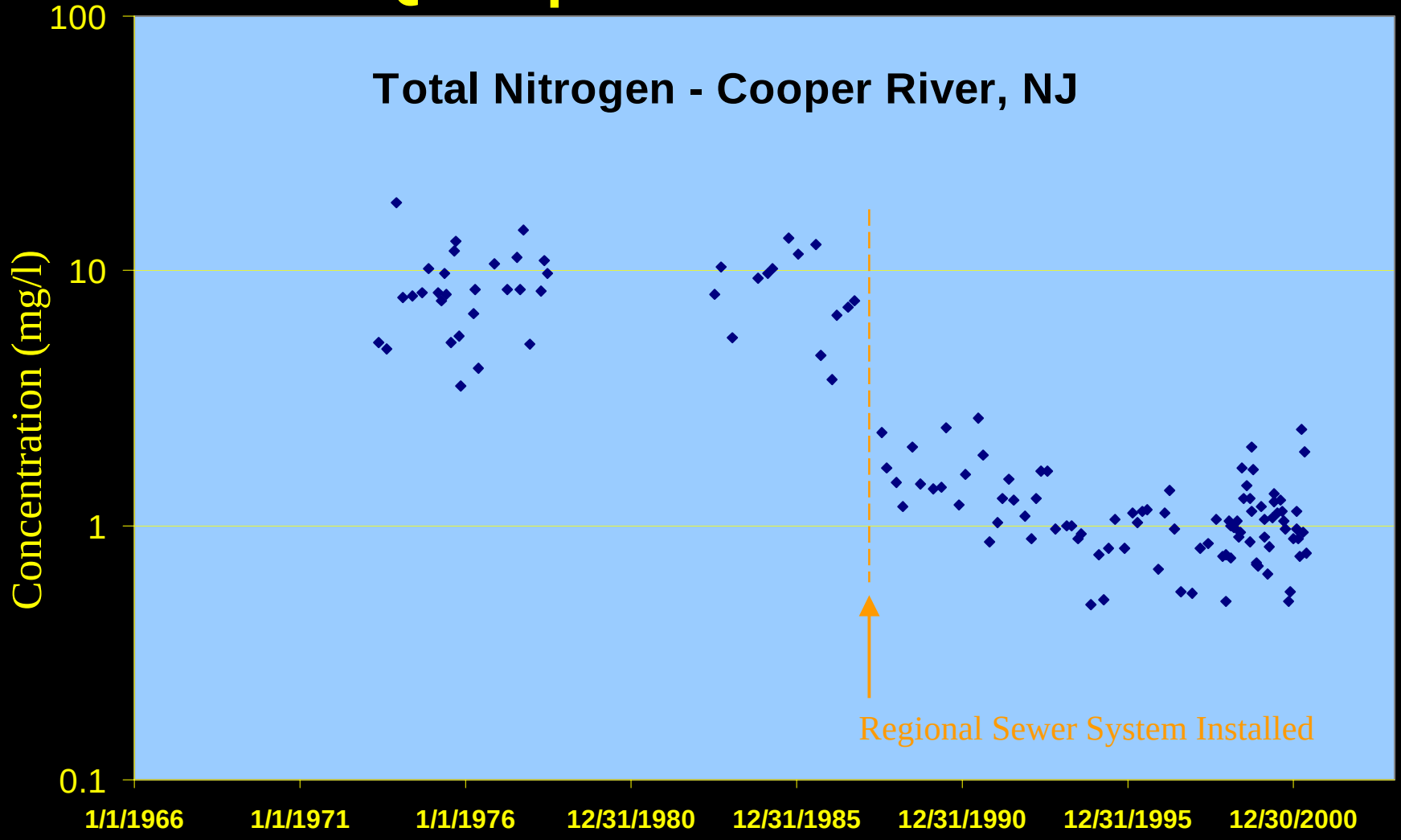
- Plans:
  - Use post 1974 data to generate predictors.
  - Calculate average load for each year 1990-2001.
  - Use 12 year average for SPARROW loads
- Comments:
  - Several versions of ESTIMATOR
  - Use of long-term quarterly monitoring data vs short-term intensive sites
  - Small research basins (<5 mi^2)
  - Sites with abrupt change in QW

Sites with short period of record and small basins

(including NAWQA sites)

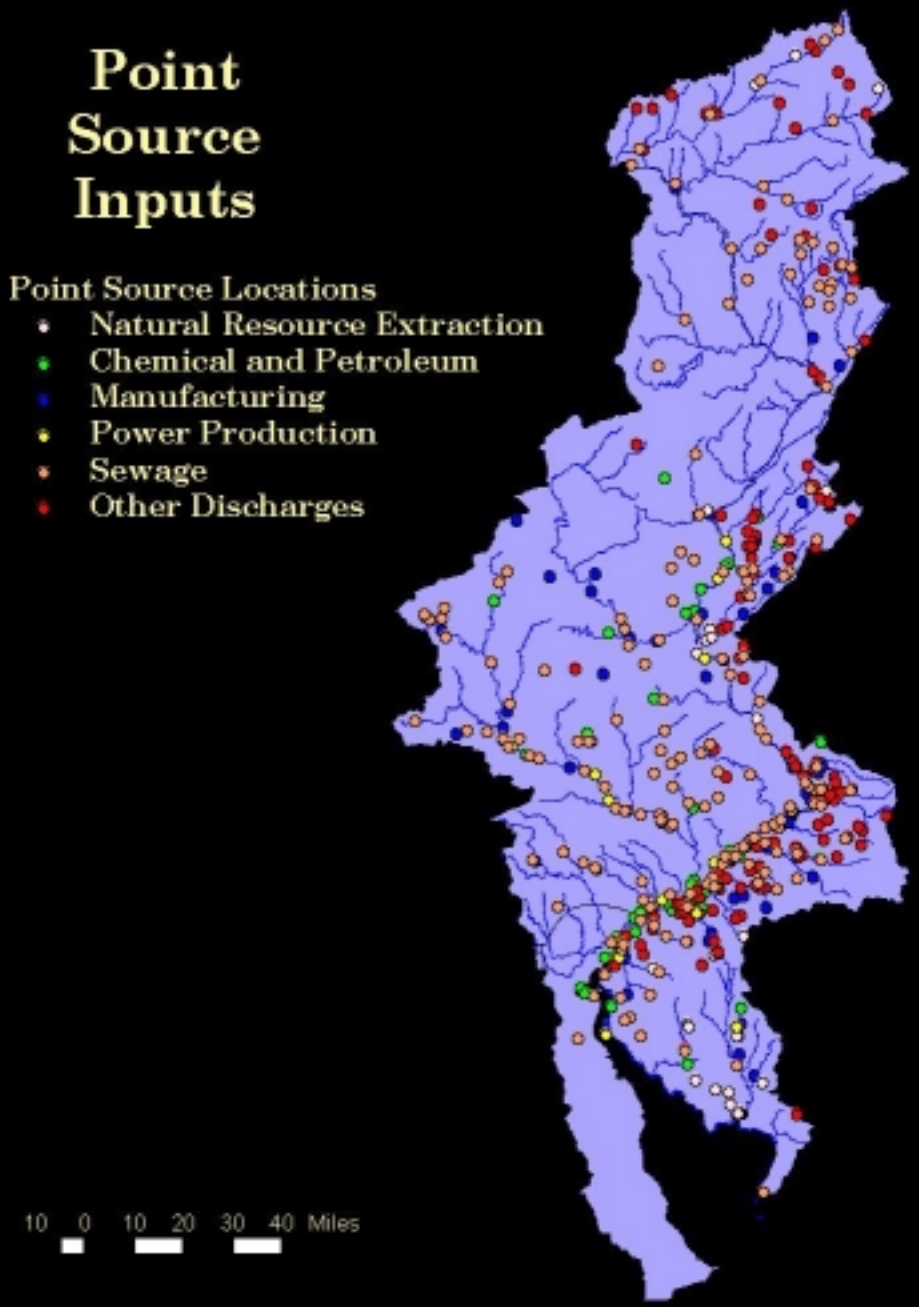


Sites with abrupt changes in QW parameters



Nutrient Data Sources

DATA	SOURCE
• Fertilizer usage, 1992 & 1997	NAWQA/USDA
• Livestock waste production, 1992 & 1997	NAWQA/USDA
• Non- agricultural land use, 1992 or 2000	MRLC data from EROS
• Atmospheric deposition, 1987-2002	National Atmospheric Deposition Program
• Point sources, 1997-2002	EPA, NOAA DRBC, state DEP's



Point Sources

Model will use EPA data from 1992 to 2002, updated with state flow and location data.

Regional sewer systems collect waste from non-tidal basins and discharge into tidal estuary.

SPARROW Model Input Data Watershed Characteristics

- Land-to-water delivery factors
  - Temperature
  - Soil permeability
  - Land Use
  - Slope
  - Others .....
- In-stream removal
  - Stream-size
  - Reservoirs

Delaware SPARROW Model Unique Aspects

- Land-to-water delivery factors
  - **Forest type and fragmentation.**
- In-stream removal
  - **Stream-size (first 1:24K model).**
- Model Comparisons
  - **Comparison with PnET Forest productivity model.**

Delaware SPARROW Model Project Plans

- ESTIMATOR load calculations - 6 mo.
- NHD area, flow, and travel time generation - 12 mo.
- Apply Overland and In-stream factors - 6 mo.
- Model Simulations - 12 mo.
- Reports
  - Estimated Nutrient Loads - 2003
  - Data
  - Delaware SPARROW - 2004

Goal: Completed model by end of 2003.

Modeling Support

- NAWQA
  - National NAWQA Program
  - Delaware NAWQA Project
  - NAWQA/State Coop for 1:24K NHD streams
- US Forest Service
  - Forest Type and Fragmentation Indexes
  - Climate and Atmospheric loading data
- US EPA
  - Point Source Loading data